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LAT Calorimeter CsI Crystal Specification</td></tr>
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Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter CsI Crystal Specification

Swedish Project No. 2143-4108

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DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1		Initial Release	
2		Vendor comments incorporated	
3			
4		Updated with new chamfer definition	

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TABLE OF CONTENTS

1 PURPOSE

This document specifies the mechanical and performance characteristics of the Thalium-doped Cesium Iodide, CsI(Tl), scintillating crystals for the Calorimeter subsystem of the GLAST Large Area Telescope (LAT). It also specifies the quality assurance and process controls, acceptance test measurements, shipping and handling requirements, and the delivery schedule for these crystals.

2 SCOPE

These specifications apply to the CsI(Tl) scintillation crystals for the Calorimeter subsystem of the GLAST LAT. The crystals shall support two development models of the LAT calorimeter and 18 flight model calorimeter modules. Each module requires 96 CsI(Tl) crystals. After testing with the development models, a final determination of the CsI(Tl) crystal dimensions shall be made prior to the flight crystal fabrication. An option for additional crystals is also specified.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
CsI or CsI(Tl)	Thalium-doped Cesium Iodide
FWHM	Full Width at Half Maximum
GLAST	Gamma-ray Large Area Space Telescope
EM	Engineering Model
FM	Flight Model
GSFC	Goddard Space Flight Center, NASA
KTH	Kungl Tekniska Högskolan
LAT	Large Area Telescope
MIP	Mandatory Inspection Points
NASA	National Aeronautics and Space Administration
NRL	Naval Research Laboratory
PIN	Positive-Intrinsic-Negative, a silicon device construction technique to provide low-capacitance, high speed photodiode response
TBD	To Be Determined
TBR	To Be Resolved

3.2 Definitions

γ	Gamma Ray
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million Electron Volts, 10^6 eV
ph	Photons

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT Calorimeter and its requirements include the following:

LAT-DS-00096-01	"Calorimeter Crystal Mechanical Test Station Requirements"
LAT-DS-00097-01	"Calorimeter Crystal Optical Test Station Requirements"
LAT-SP-00010	"GLAST LAT Performance Specification", August 2000
LAT-SS-00018	"LAT CAL Subsystem Specification", January 2001
GLAST00110	"Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", NASA Goddard Space Flight Center, Current Draft Sept 20, 2000
NPD 8010.2B	"NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"

5 INTRODUCTION

The GLAST mission is a NASA-launched gamma-ray mission to be launched in 2005. The expected mission lifetime is greater than 5 years. The Large Area Telescope (LAT) instrument is the primary experiment on GLAST and consists of an Anticoincidence Device, a silicon-strip detector tracker, a CsI(Tl) calorimeter (CAL), and a Trigger and Dataflow system. The principal purpose of the LAT is to measure the incidence direction, energy and arrival time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The LAT calorimeter is a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4 × 4 array of identical modules. Each module is a hodoscopic array of 96 CsI(Tl) scintillation crystals and associated readout electronics. Each crystal is approximately 26.7 × 19.9 × 326.0 mm in size with a PIN photodiodes attached on each end.

Two photodiodes, one large and one small, are required at each end of the crystal to support the electronic measurements over the required dynamic range of the energy depositions. The diodes shall be coupled to the CsI(Tl) crystal using an optical epoxy or a silicon elastomeric casting (similar to Mapsil 213).

Crystal logs are placed in a carbon fiber supporting structure with 0.4 mm wall thickness and with a rectangular opening 27.35 mm wide and 20.50 mm height. The crystals are kept in position using a rubber string in each corner of the opening. Crystals therefore have chamfered edges along the four long sides.

The overall goal is to have crystals that meet or exceed light output and uniformity specifications below. Crystals must also meet mechanical tolerances to allow their integration into the supporting structure.

6 REQUIREMENTS

6.1 Mechanical Configuration

The CsI(Tl) crystals shall be rectangular parallelepipeds with a chamfer on the edges of the long dimension. Figure 1 shows the mechanical configuration and tolerances for the crystals.

6.1.1 Overall dimensions (mm) at 20° C

Length	326.0 mm
Height	19.9 mm
Width	26.7 mm

6.1.2 Tolerance on dimensions (mm):

Length	+ 0.0, –0.6 mm
Height and Width	+ 0.0, –0.4 mm

6.1.3 Chamfered edges.

The four 326 mm edges of the crystal shall have a 45° chamfer defined by the diagonal distance between two opposing parallel chamfers (see Figure 1a and 1b), which is necessary for proper fit into the composite structure cell with its elastomeric cords in place.

Diagonal spacing between two opposing parallel chamfers:	31.68 mm, tolerance ± 0.10 mm
Chamfer angle:	45°, tolerance ± 5°

6.1.4 Surface flatness, parallelism:

6.1.4.1 Placed on a flat plane, no point on the crystal face against the flat plane must deviate from the plane by more than 0.20 mm.

6.1.4.2 Placed on a flat plane, no point on the crystal face parallel to the plane in contact with the flat plane must deviate from 19.7 mm (average height) or 26.5 mm (average width) by more than 0.20 mm.

6.1.5 Perpendicularity

6.1.5.1 The end faces of the crystal shall be perpendicular to the side faces and no point shall deviate from the perpendicular by more than 0.3 mm.

6.1.5.2 The adjacent side faces of the crystal shall be perpendicular to each other and no point on one of those sides shall deviate from the perpendicular by more than 0.3 mm.

6.1.6 Surface treatment:

6.1.6.1 Crystals shall have no visible scratches, cracks or dents.

6.1.6.2 The two ends of the crystals shall have a surface finish of TBD µm. The four long sides shall be treated to provide the required light tapering.

6.2 Optical Performance

6.2.1 Light yield

The light yield and its uniformity is specified in terms of the energy resolution for the 1275 keV gamma-ray line from a collimated Na-22 source. The signals from each 5 cm diameter photmultiplier tube in contact with the two ends of a crystal log shall have a FWHM (Full Width Half Maximum) of less than or equal to 13% with the source at any of eleven (11) evenly spaced points starting 2 cm from one end and finishing 2 cm from the other end of the log. During this test the crystals should be surrounded by two turns of highly reflective white Tyvek. For each crystal the results of the measurements should be provided. The equipment to measure the light yield is provided by the buyer. (see section 7.7).

6.2.2 Light Yield Uniformity

The absolute light yield of the array of crystals shall not vary from crystal to crystal by more than 10% from the mean value. This shall be determined by using average of the light yields measured at the eleven sampling points identified in section 6.2.1. This average light yield, when corrected for instrumental effects of photo-multiplier gain, shall be the same for all crystals to within 10%. Instrumental gain corrections shall be determined by using a reference sealed crystal provided by the buyer. The buyer-provided reference crystal shall be a 5-cm diameter × 5-cm long right cylindrical CsI(Tl) crystal packaged in a hermetic metal can with an optical window.

6.2.3 Light Tapering

The four long sides of the crystals shall be roughened so that light tapering is achieved. The tapering shall be monotonic along the crystal and such that with the source 2 cm from one end the light collected at the far end is 60 ± 10 % of the light collected by the PMT close to the source. Light tapering shall be measured at the same 11 points indicated in 6.2.1.

The light yield measuring device as well as the covering material Tyvek is provided by the buyer. The buyer shall also provide tape to be used on wrapping materials. The tape will be transparent kapton-based tape. No other adhesive tape is to be used by the supplier in wrapping the crystals.

6.2.4 Radiation Hardness

After radiation with 10 krad gamma-rays from a Cobalt-60 source the light yield shall not be reduced by more than 50%. The radiation hardness of all crystals in a boule shall be judged by the radiation hardness of a sample from the boule (section 7.3). If the sample fails the radiation test, all crystals from that boule will be rejected. It is anticipated that the boule sample will be delivered to the buyer and radiation tested by the buyer before any additional crystals are manufactured from the boule.

7 QUALITY CONTROL AND INSPECTION

The supplier shall plan and follow processes which directly affect the quality of the CsI(Tl) crystals. The supplier shall monitor, control and maintain process parameters to ensure that the product characteristics fall within required specifications and/or tolerances. The supplier shall establish and follow documented procedures for inspection activities to verify that the product requirements are met.

7.1 Crystal identification

7.1.1 Purpose

Each crystal should have a serial number that clearly specifies the boule from which it was manufactured and the location in that boule. The serial number shall be unique for all crystals within this contract.

7.1.2 Implementation

The crystal identification number shall be affixed on the outside of the wrapper, in a manner that will not be erased by contact with alcohol. The information on location of a crystal in a boule shall be given by drawings showing crystal ID numbers and their locations within a boule.

Furthermore, a “>” reference mark shall be scribed directly onto the 26.7 mm surface of the right end of the crystal.

7.2 Crystal cleanliness

All traces of oils or greases used in the manufacturing or testing processes must be removed.

7.3 Boule samples

For each boule two samples should be provided in the form of highly polished cylinders, 2.5 cm diameter and with 2.5 cm height.

7.4 On site inspections

Crystal manufacturing facilities shall be subject to inspection, surveillance, and test at specified periodic intervals and places. Mandatory Inspection Points (MIPs) and visits will be notified and negotiated prior to crystal manufacturing. During MIP inspections, surveillance and tests will be witnessed or performed not to unduly delay the work but to verify quality during process.

The supplier shall provide 100% dimensional inspection reports documenting each required and actual dimension using the buyer-provided mechanical test bench described below and in referenced document, LAT-DS-00096-01, “Calorimeter Crystal Mechanical Test Station Requirements”.

The inspection reports shall be supplied using a mutually agreeable electronic media and format.

7.5 Buyer-provided mechanical test bench

7.5.1 The buyer shall provide a mechanical test bench to verify all required dimension measurements. The test bench shall be provided along with documentation and procedures for use.

7.5.2 Description

The mechanical test bench is defined in referenced GLAST document LAT-DS-00096-01, “Calorimeter Crystal Mechanical Test Station Requirements”. A short summary of the test bench is given below.

The mechanical test bench measures every long side of the crystal at six points using an array of digital gauges. Values from the digital gauges are summarized in a computer and the dimensions of the crystal are calculated. The chamfer is measured at three points. The short ends are measured only as the total length of the log. The results are presented in standard format for machining industry. The results will also indicate if the log has a bend or twist. The measuring cycle takes approximately 10 minutes. Additional time will be added for handling, visual inspection and cleaning.

7.5.3 Operation and Maintenance

The buyer shall provide the test bench for the supplier’s use in crystal verification and inspection. The measurements with the buyer-supplied bench represent the minimum required measurements. The supplier is free to provide measurements using his own procedures and equipment in addition to this minimum. The supplier shall promptly report any breakdown or malfunction in the test bench. Maintenance of the test bench is the buyer's responsibility.

7.6 Required performance measurements

The supplier shall provide performance inspection reports for 100% of the crystals delivered on this contract. These reports shall document each required and actual performance measurement on the crystal using the buyer-provided optical test bench described below and in referenced document, LAT-DS-00097-01, "Calorimeter Crystal Optical Test Station Requirements".

The inspection reports shall be supplied using a mutually agreeable electronic media and format.

7.7 Buyer-provided optical test bench

7.7.1 The buyer shall provide an optical test bench to verify all required performance measurements. The test bench shall be provided along with documentation and procedures for use. The supplier shall be responsible for providing the Na-22 radioactive source required to use the optical test bench. The mechanical and radioactivity specifications of this radioactive source shall be provided by the buyer.

7.7.2 Description

The optical test bench is defined in referenced GLAST document LAT-DS-00097-01, "Calorimeter Crystal Optical Test Station Requirements". A short summary of the test bench is given below.

The crystal light yield and light taper are measured with photo-multiplier tubes on the two small faces of the crystal and a remote-controlled motor-driven radioactive source irradiating the crystals from a perpendicular direction. The photo-multiplier tubes are Hamamatsu R669 photomultiplier tubes and are 5 cm in diameter. The radioactive source is a 3.7×10^5 Bq (10 microCurie) Na-22 source held in a lead pig with a collimating hole. This arrangement is mounted in a light-tight box with easy access to change out crystals and reposition the photo-multiplier tubes and apply pressure against the face of the crystals. The optical coupling between the photo-multiplier tube and the crystal is a dry contact. The photo-multiplier tubes are readout by standard NIM-bin based laboratory nuclear electronics. The electronics consist of a dual high-voltage power supply, a dual shaping amplifier, 2 ADCs and a custom electronics card that generates coincidence triggers, keeps track of dead-time, and acts as the interface to a PC. The motor is controlled through a Labview program. The same computer program controls the motor, acquires the data, analyzes and archives the data. When a log is inserted in the box and the program started, the program will automatically move the source to a predetermined set of positions and log data for a predetermined amount of time. The program written in Labview is installed on a PC that acts a data acquisition system and logs all data electronically.

7.7.3 Operation and Maintenance

The buyer shall provide the test bench for the supplier's use in material verification and inspection. The measurements with the buyer-supplied bench represent the minimum required measurements. The supplier is free to provide measurements using his own procedures and equipment in addition to this minimum. The supplier shall promptly report any breakdown or malfunction in the test bench. Maintenance of the test bench is the buyer's responsibility.

7.8 Required Documentation

For each crystal, mechanical dimensions and performance measurements shall be given for each point measured. Documentation shall follow a data format provided by the buyer. Data shall be provided by supplier on electronic media.

7.9 Control of nonconforming product

The crystal supplier shall establish and follow documented procedures to ensure that product that does not conform to crystal requirements is not delivered to the buyer. This control shall provide for identification, documentation, evaluation, segregation, and disposition of nonconforming product, and for notification to the functions concerned.

Nonconforming crystals may be:

1. Reworked to meet requirements.
2. Accepted with or without repair by concession.
3. Reclassified for alternate application.
4. Rejected and scrapped

Repaired or reworked crystals shall be re-inspected to ensure that they meet requirements.

8 HANDLING AND SHIPPING

The crystal supplier shall pack the crystals to prevent damage and deterioration to the quality and performance of the crystals. Packaging and handling shall be performed as TBD procedures and materials. Supplier is responsible for damage to or deterioration of any goods resulting from improper packing or packaging.

Supplier will ship the goods according to the following instructions:

1. Shipping Documentation: Must include packing sheets containing purchase contract number, line item number, description and quantity of goods shipped, part number or size, inspection reports, test data, and other documents as defined in the previous sections. A shipment containing hazardous and nonhazardous materials must have separate packing sheets for the hazardous and nonhazardous materials. The shipping documents will describe the material according to the applicable classification and/or tariff. The total number of shipping containers will be referenced on all shipping documents.
2. Shipping Container Labels: Supplier will label each shipping container with the purchase contract number and the number that each container represents of the total number being shipped (e.g., Box 1 of 2, Box 2 of 2).

Crystals should be shipped in vacuum sealed plastic bags and in such a way that the shape of each crystal is preserved. Each shipping container shall be water proof and shall contain a maximum of 12 crystals.

The supplier shall provide appropriate shipping containers for the transport of the finished crystals to the buyer. Each container shall hold no more than 12 crystals (details to be negotiated). The supplier shall insure that the crystals are mechanically supported with appropriate material as to preserve mechanical shape of the crystals during all phases of transport.

9 DELIVERY SCHEDULE

9.1 Delivery point

The delivery point for the crystals shall be defined in the contract.

9.2 Required crystals

13 crystals	On May 1, 2001
11 crystals	by June 1, 2001
106 crystals	By 1 August, 2001, (assuming working test bench equipment delivered by buyer at Amcrys by 31 May)
110 crystals	By 1 April, 2002
1800 crystals	Between 1 July 2002 – 1 April 2003 with monthly deliveries. A minimum of 200 crystals delivered per calendar month

Note: The first 24 crystals delivered by the supplier will not be tested in the seller's facility using the buyer-provided test equipment. The supplier shall use his own facilities to verify that these crystals meet the specifications and the buyer shall verify this with measurements upon delivery. The buyer shall deliver to the seller the specified test equipment by 31 May 2001 for required testing of all subsequent crystals.

9.3 Optional crystals

At the option of the buyer, up to 200 additional crystals can be purchased with delivery 1 April 2003. Exercise of the option shall be decided no later than 1 October 2002

9.4 Change of dimensions

Slight changes to the dimensions of the crystals should be possible after the delivery of the first 130 crystals before the start of the manufacturing of the large batch of 1800 crystals, i.e. before 1 March 2002. These changes are maximum 4 mm in crystal length and 2 mm in width or height and 1 mm in bevel length.

10 ACCEPTANCE AND REJECTION

10.1 Incoming Inspection

On delivery, the buyer shall perform inspections on each crystal using similar mechanical and optical test stations identified in sections 7.5 and 7.7. The nonconforming crystals shall be returned for credit or refund, and the supplier is expected to promptly correct or replace the crystals. Crystal supplier shall not redeliver corrected or rejected goods without disclosing the formal rejection or requirement for corrective action in writing.

The buyer shall perform acceptance tests on delivered crystals at a rate of at least 50 crystals per week.

10.2 Radiation Hardness

The radiation hardness of all crystals in a boule shall be judged by the radiation hardness of a sample from the boule (section 7.3). This test will be performed by the buyer on one of the crystal samples from each boule. If the sample fails the radiation test, all crystals from that boule will be rejected.

10.3 Late delivery

The buyer requests a penalty in case delivery of crystals following specifications in 3 above are not made according to delivery plan. The penalty rates should be 1% per week, maximum 7,5% according to the General Regulations of 1981, ALOS 81, and Article 17.

10.4 Cancellation clause

If in any delivery of at least 100 crystals more than 10% (ten percent) do not fulfil the crystal specifications the buyer has the right to cancel the order.

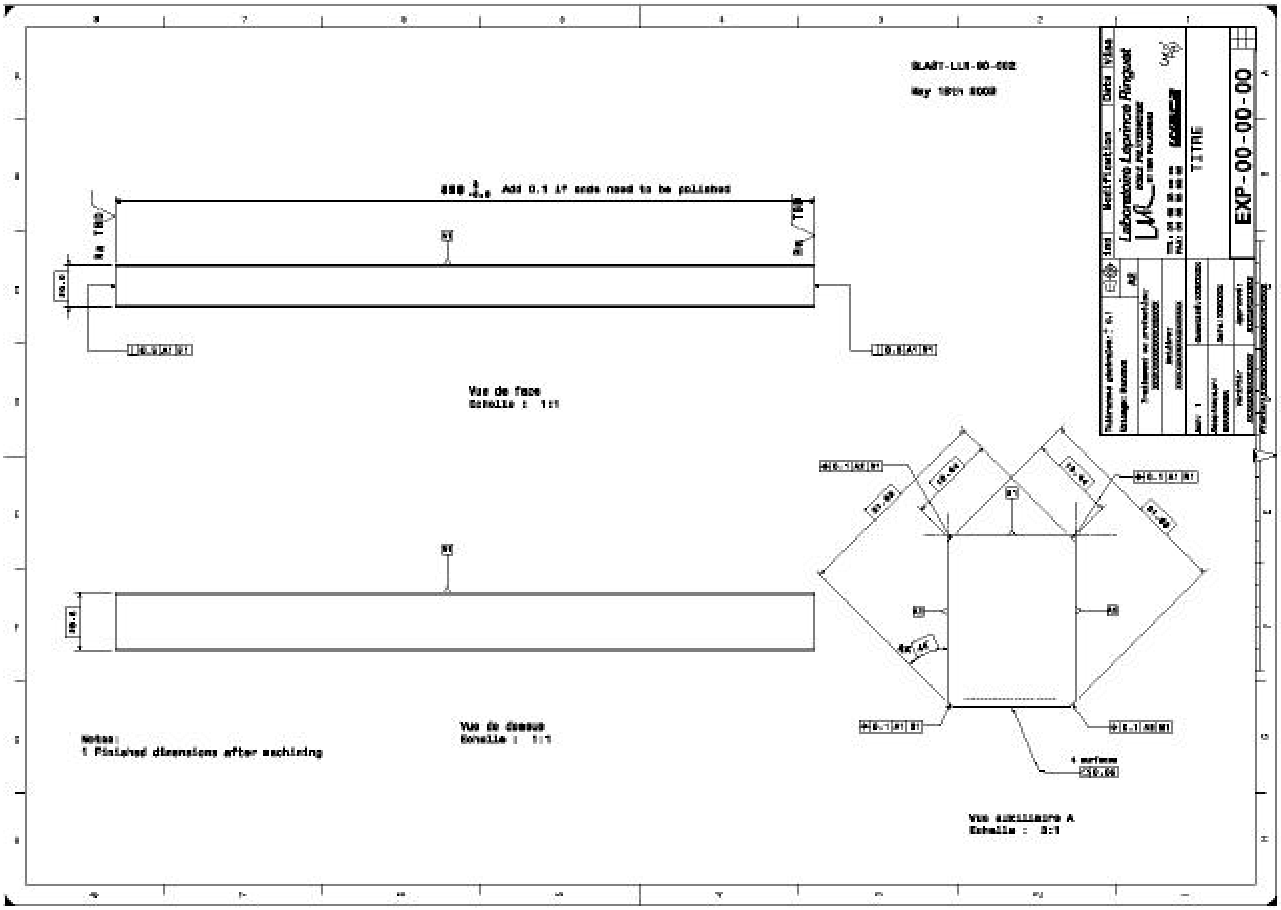

Figure 1a. CsI Crystal Machined Dimensions and Tolerances

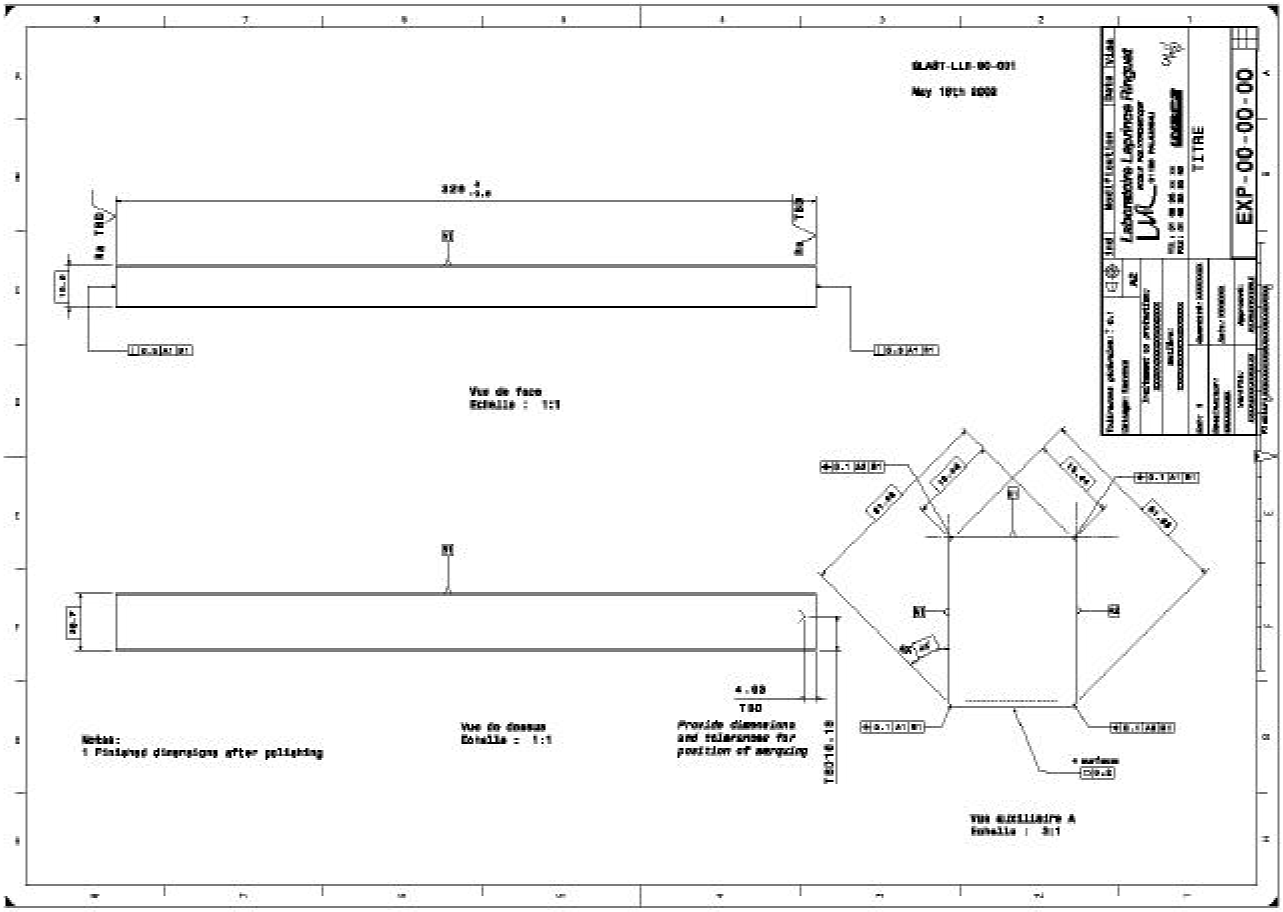

Figure 1b. CsI Crystal Polished Dimensions and Tolerances